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The Potential of Brachiaria Grass in the Smallholder Dairy Fodder Flow Systems: A Review

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Abstract

Brachiaria grass (*Urochloa brizantha*) is a perennial grass that is native to most parts of Africa. The grass was enhanced in a tropical region of Latin America, where it revolutionized both animal and grassland cultivation. Its traits have conclusively demonstrated that Brachiaria grass may increase cattle productivity in its native land in many areas of Africa, particularly in East Africa. Since pastures provide the majority of the feed for smallholder dairy animals, it is necessary to investigate the possibility of incorporating these modified native grasses into smallholder dairy fodder flows. Improved native grasses must be incorporated into dairy fodder flows because of declining pasture growth patterns and seasonal fluctuations in pasture nutritional composition. The impressive results recorded in foreign lands together with some experimental results in East and Central Africa indicate that Brachiaria can have a significant impact on dairy production. This paper, therefore, reviews research work done in Africa on Brachiaria to stimulate further research works by others.

Keywords

Brachiaria; Smallholder dairy; Fodder flows; Africa

1. Introduction

The economy and way of life of farmers are heavily impacted by the production of livestock, particularly dairy. In many nations, including Zimbabwe, smallholder dairy farming is the future of the dairy industry. Currently, small-scale dairy producers in Kenya provide roughly 74% of the milk produced there (Kassie et al., 2018). The dairy sector is currently faced with a variety of difficulties, including a restricted supply of high-quality feed resources, due to severe land and other abiotic and biotic limits

and substantial postharvest losses as a result of inadequate fodder conservation strategies (Ghimire et al., 2019). The main causes of low livestock output among these limitations are insufficient and poor-quality feeds, with restricted use of foraged plants as a source of animal feed. Smallholder farmers are mainly constrained by feed scarcity, which is associated with seasonality in rainfall, poor fodder production techniques and poor feed quality, and limited land for fodder production (Mureithi and Djikeng 2016). Natural pasture hectarage has shrunk over the years due to increased cropping than livestock rearing, and the pasture productivity has been declining due to overgrazing, poor pasture management, and drought (Mutimura and Everson, 2012).

One method of addressing the rising demand for milk is the intensification of the dairy production system. Sustainable fodder production systems are needed to boost animal productivity, but they are currently under danger due to rising feed prices and an extended drought. Therefore, a long-term remedy that can be used to address the existing condition is the production of enhanced planted forages. As a substitute for traditional feed sources, stakeholders in the cattle industry are promoting the climate-smart fodder known as Brachiaria grass. Developing fodder source for cattle production, particularly for smaller dairy farms, can be achieved through the grass Brachiaria. Due to its excellent productivity under heavy use, tolerance to low soil fertility, and relatively low infestation of pests and illnesses, the Brachiaria grass species is a climate-smart grass (Mupenzi, 2016). Because it provides good ground coverage, it can survive intense grazing, and grows on rocky and poor soils helping erosion control. In terms of nutritional value data, Brachiaria fodder is extremely palatable to livestock, resulting in high consumption whether fed fresh or let to graze in the field. Previous studies on Brachiaria have revealed that it produces a lot of biomasses and has nutrient-rich herbage; therefore, it has the potential to boost cattle output (Holmann et al., 2004). It can increase the effectiveness of using nitrogen, store carbon, and adapt to drought and soils with low fertility (Arango et al., 2014; Moreta et al., 2014; Rao et al., 2015). The potential of Brachiaria grass as a source of feed has been evaluated through a number of research (Machogu, 2013; Nguku, 2015; Njarui et al., 2016).

In the tropical and subtropical regions of the world, Brachiaria grass is one of the greatest forages for enhancing forage production, year-round forage availability, and animal productivity while also addressing the problems of climate change. This paper's main goal is to assess the advantages of enhanced Brachiaria grass on smallholder dairy farms.

2. Potential of Bracharia Grass to Transform Smallholder Dairy

The supply of high-quality forage is increased by improved pastures, which also yield high-quality green plants, boost dairy productivity, and provide feed all year long, including during the dry season. Enhancing forages can increase the potential of smallholder dairy herds and can decrease the requirement for feed supplements. Low forage yields are a result of pastures being produced on infertile soils that are unsuitable for food crops in the majority of smallholder dairy groups. The majority of animal feeds in developing nations like Zimbabwe, Kenya, and Rwanda are gathered from various native or introduced tropical pasture species. These native pastures might not be very nutritious, which would result in low productivity making it difficult to support livestock production, especially dairy production.

Particularly in Brazil, Brachiaria has had a significant impact on how the livestock industry has changed throughout tropical America (Jank et al., 2014). Brachiaria grass has a considerable impact on cattle productivity, supporting its significant role in the intensification of the livestock production system in Africa (Mutimura et al., 2016; Njarui et al., 2016). Since Brachiaria grass was introduced in Africa, evaluations of its adaptability, nutritional value, livestock production, and greenhouse gas emission have

revealed that the grass has the potential to boost animal productivity while reducing greenhouse gas emissions. According to studies on the fodder suitability map, Brachiaria grass varieties are suitable for the majority of the agroecologies in Southern African nations, while there may be some alterations as a result of climate change. Brachiaria grass has the potential to be embraced and used by farmers who are engaged in dairy farming, particularly on a small scale, as it is adaptable to varied ranges of agro-ecologies across the globe. The Brachiaria grass' growth patterns are compatible with small-scale farming. This is so that less land can be wasted by planting it along terrace banks or farm boundaries.

This indicates that grass has the ability to transform the cattle industry regardless of the size of the land a farmer may own. This is so that feed shortages, especially during the dry season, can be addressed. Smallholder farmers can plant grass in any suitable niche, harvest it, and store it as hay. Under conditions of rain-fed growth, Brachiaria grass can be harvested at least five times annually and it quickly regenerates (Mutimura and Everson, 2012).

3. Utilization and Conservation of Bracharia Fodder

Brachiaria grass is a high-quality tropical grass that is indigenous to East and Central Africa. In South America, Australia, and East Asia, it is commonly produced for hay production, silage production, and grazing. Native to Eastern and Central Africa, Brachiaria species are widely cultivated as animal pasture in South America and East Asia (McGuire, 2015). Brachiaria grasses are better known for their high dry matter (DM) content and their high crude protein (CP) content. Research was conducted at Grasslands Research Institute between 1990 and 1993 to evaluate DM and CP content of six Brachiaria species, which are:

1. *Brachiaria arrecta,*
2. *Brachiaria bovonei,*
3. *Brachiaria brizantha,*
4. *Brachiaria decumbens,*
5. *Brachiaria humidicola,*
6. *Brachiaria subulifolia*

Estimated parameters of the grass are summarized in the table 1.

Table 1: Dry matter, crude protein and yield per hectare of selected brachiaria grasses at Grasslands Research Institute

Brachiaria species	*Dry matter content (%)*	*Crude protein content*	*Yield (t/ha)*
1. Brachiaria arrecta,	26.09	15.73	1.24
2. Brachiaria bovonei,	39.86	8.68	1.24
3.Brachiaria brizantha	34.09	15.07	2.56
4.Brachiaria decumbens,	31.88	14.68	12.54
5. Brachiaria humidicola	25.39	15.20	3.50
6. Brachiaria subulifolia	33.04	12.20	0.35

Source: Karwat et al., 2017

In the humid tropics, Brachiaria grasses are among the most nourishing forages. For instance, according to Nguku (2015), *B. brizantha* has a 10% (range: 5 to 16%) crude protein (CP) content in dry matter, 66% neutral detergent fibre (NDF), and 58% in vivo organic matter digestibility. In Cameroon, the dry season saw an increase in NDF and acid detergent fibre (ADF) and a drop in CP for *B. ruziziensis* from 15.6% to 5.4% and 34.2% to 48.6% to 70.5% to 76%, respectively, compared to the wet season (Pamo et al., 2007). Nitrogen use in Tanzania enhanced *Brachiaria brizantha* yield from 6.0 to

26.5 t/ha (Urio et al., 1988). Its large, pliable leaves that are highly palatable are preferred for ease of consumption as fodder (Costa et al., 2013).

Brachiaria brizantha cv. Piata was found to be a better source of protein than Mulato II and Rhodes grass in research by Ngila et al. (2016), on changes in growth of Galla goats fed a variety of Brachiaria grass cultivars in the coastal lowlands of Kenya. It had the 7.5% minimum CP, which Van Soest et al. recommended for optimal rumen function and production (Van Soest et al., 1994). Crude protein (CP) and digestible dry matter are the two elements of a diet that are considered to be the most crucial, according to Ullah et al. (2007). For pregnant ewes, does, and finishing kids, the necessary crude protein amounts to 9.6, 11.2 and 11.7%, respectively (NRC, 2007).

According to the study by Muinga et al. (2016) on the effects of Brachiaria grass cultivars on the lactation performance of dairy cattle in Kenya, milk production increased on average from 4 litres to 4.6 litres per cow per day for animals with low yields, or a 15% increase, and from 9 litres to 12.6 litres per cow per day for dairy cattle with relatively higher yields, or a 40% increase. This shows that Brachiaria is superior to the feeds that the local farmers in the area utilized during the study period.

Due to a lack of feed, smallholder dairy farms in the tropics have difficulty raising heifers to replace dairy cows. In Rwanda's cut-and-carry feeding system, Mupenzi (2016) tested Brachiaria hybrid cultivar Mulato II as a feed resource for enhancing dairy heifer growth performance. Heifers fed a diet based on Brachiaria did not statistically vary from those fed a diet based on commercial concentrate, although they did increase more body weight on a daily basis. Mulato II is a forage grass that can be incorporated into a cut-and-carry feeding system in smallholder farms to feed heifers intended to replace dairy mature cows, taking into account DM and nutrient intakes as well as the quality abilities of Mulato II.

Table 2: In vitro digestion parameters of Brachiaria grasses harvested at 90 days after planting

Forage variety	*GP (ml/gDM)*	*A (g/kgDM)*	*B (g/kgDM)*	*C (%/h)*	$T_{1/2}$ *(h)*
B. hybrid cv Mulato 2	243	66	177	0.029	19
B. hybrid cv Mulato	253	96	155	0.029	19
B. hybrid cv Cayman	218.3	0.2	218.1	0.032	26.6
B. brizantha cv Piata	266	69	197	0.032	20
B. brizantha cv Xaraes	210	50	160	0.025	23
B. brizantha cv MG4	234	87	148	0.028	20
B. brizantha cv Marandu	188	65	124	0.028	22
B. decumbens cv Besilik	240	70	170	0.033	20
B. humidicola cv Humidicola	216	61	155	0.033	22
B. humidicola cv Llanero	253	86	168	0.028	21
Napier grass *(P. purpereum)*	243	65	178	0.028	26

Where: A – fast degradable fraction, B – slowly degradable fraction, C – rate of degradation, $T_{1/2}$ - time to produce half of the gas [*Source:* Mutimura et al. (2016)]

4. Socio-Economic Benefits of Bracharia Grass on Smallholder Dairy

Farmers stated that they would prefer grasses that are simple to cultivate, productive, drought-tolerant, tasty, and high in nutrients (Njarui et al., 2016). The creation of perennial pasture plots adjacent to homes reduced the amount of time and labour required to graze livestock by an average of 50% (Nicholson et al., 1999). Long distance travel is uncomfortable for dairy cows because it lowers milk production. The cut and carry approach shorten the time needed to herd the cattle, freeing up labour for other tasks like housework and crop cultivation. The adoption of Brachiaria led to an

increase in female participation in the dairy industry, encouraging gender equality in the dairy farming industry. Previously, fewer women worked in the dairy industry, but the introduction of Brachiaria led to an increase in female participation, as is the case in Kenya's coastal lowlands (Njarui et al., 2016). Brachiaria grass was used in the participatory evaluation of cultivars for livestock production in Kenya's coastal lowlands, which resulted in a 20% increase in the participation of women.

Table 3: Number of farmers involved in participatory evaluation of Brachiaria disaggregated by gender

Agroecological zone	*April*			*July*		
	Male	Female	Total	Male	Female	Total
Coastal low lands 3	19	31	50	22	36	58
Coastal low lands 4	29	15	44	28	19	47
Coastal low lands 5	7	9	16	9	11	20
Total	55	55	110	59	66	125

Source: Njarui et al. (2016)

Brachiaria cultivation enhances household income because it boosts milk production by 27.6% in both Eastern and Western Kenya (Maina et al., 2021). The results of Muinga et al. (2016) and Kabirizi et al. (2013), who found that cows given Brachiaria enhanced their milk yield by 15–40%, are compatible with this. Similar to this, Njarui et al., (2016) reported that the hybrid Brachiaria variety Mulato II boosted milk output by 23% during the rainy season and by 11% during dry months. According to Kassie et al. (2018), those who adopted climate-smart push-pull methods utilizing Brachiaria had noticeably higher milk yields compared to those who did not. As a result, Brachiaria can supply high-quality feed all year round and raise animal output. According to Mureithi and Djikeng (2016) feeding beef cattle with Brachiaria grass resulted in daily weight gains of 0.44 kg/head for each animal. During times of feed stress, it is projected that the use of Brachiaria in smallholder dairy farming systems boosted feed sufficiency by 31.6%. Brachiaria grass use has been proven to have favourable effects on milk production and feed sufficiency levels, leading to improved income, according to rigorous econometric approaches.

Brachiaria grass generates income through the sale of planting material and conserved feed in addition to increasing dairy productivity. In addition to increasing milk output, the implementation of sustainable fodder systems would also enhance revenue from the sale of the fodder. There is evidence that the intensification of livestock production may lead to a greater reliance on resources for off-farm feed, which could lead to the development of feed and fodder markets as a result of rising feed demand (Bosire et al., 2016; Nangole et al., 2011). Maina et al. (2021) found that Brachiaria has a lower opportunity cost than the Napier grass.

Table 4: The opportunity cost of growing Brachiaria grass

	Napier grass (opportunity cost)	*Brachiaria grass (opportunity cost)*	*Transitional heterogeneity (ATT - ATU)*
Annual gross margin per acre (USD[5])	578.25 (578.25)***	657.99 (243.93)***	79.74

Source: Survey data (Maina et al., 2015)

***represents significance at the 1% level. The figures in parentheses are standard deviations; ATT: Treatment effects on the treated; ATU: Treatment effects on the untreated.

Positive transitional heterogeneity (TH) indicates that there are underlying disparities among the farmers. When compared to farmers of Napier grass, farmers of Brachiaria grass had better gross margins and, thus, reduced opportunity costs. Therefore, if

Napier grass farmers were to think of fodder production as a business, they would be worse off than Brachiaria farmers. For instance, a rooted tiller/one split cost roughly +0.02 USD whereas a 10 kg hay bale cost about 2.2 USD (Maina et al., 2021). Through the production and sale of hay and vegetative planting materials as seeds to livestock owners, Brachiaria grass can be a source of income.

5. Ecological Benefits of Bracharia Grass

Brachiaria is a high-biomass fodder with a deep root structure. Because of its morphological qualities, the soil is better bound together and more stable, preventing erosion (Santos et al., 2013). The grass provides an excellent ground cover and can survive heavy grazing, making the soil less prone to erosion. While conserving the natural resource base, Brachiaria boosts productivity. The fodder is a climate-smart grass that has a high tolerance for drought. On rocky, acidic soils where other plants cannot survive, it can quickly colonize and establish itself (Arango et al., 2014; Moreta et al., 2014; Rao et al., 2014). High acidity prevents root growth of various plants because of the prevention of the uptake of minerals and water. Brachiaria grass is different from other grasses in that it does better in acidic and nutrient-rich soils. As a result of better soil aeration and nutrient cycling, production of grass increases and the soil becomes healthier and more conducive to other plants' growth (McLaughlin and Kzsos, 2005; Vågen et al., 2005). Due to its capacity to prevent nitrification through biological nitrification inhibition, the forage has a high efficiency in using nitrogen (BNI). They aid in reducing greenhouse gas emissions by fixing atmospheric carbon into the soil (Santos et al., 2013). Pests and diseases also do not affect Brachiaria like other grasses such as Napier fodder.

Additionally, it can increase soil fertility and lessen crop pests and diseases. For instance, *Brachiaria hybrid* cv. Mulato II shown in a push-pull experiment carried out in Rwanda that it favourably reduces the infestation of fall-army worm (FAW) on maize (Mupenzi, 2016). Brachiaria species have similar characteristics to Napier grass (Pickett et al., 2014) with the added benefit of suppressing biological nitrification, which releases nitrous oxide from soil nitrogen (Subbarao et al., 2009).

Brachiaria grasses are notable for their capacity to increase soil fertility through the reduction of greenhouse gas emissions by sequestering significant amounts of CO_2 and N_2O. The crop-livestock combination can use Brachiaria grass, a fodder with high nutritional value, to boost soil carbon levels and livestock production, including milk and meat yields. The *Brachiaria hybrid* Mulato II and Napier grass were compared as the only diet for producing replacement dairy heifers, and the ruminant model (Herero et al., 2008) anticipated highly significant differences between the two grasses. In addition to the other characteristics produced by the model, it was discovered that the daily volumes of methane (L/day) and volumes of methane per unit weight gain (L/kg body weight gain) between *Brachiaria hybrid* cv. Mulato II and Napier grass were highly significant. *Brachiaria hybrid* cv. Mulato II produced less enteric methane than Napier grass (126.8 L/day vs. 145.9 L/day) (Maass et al., 2015). This indicates that in addition to its nutritional benefits, Brachiaria grass makes a good feed to reduce enteric methane output in ruminant animals.

6. Conclusion and Recommendations

The majority of the pastureland in tropical Africa is made up of the popular grass genus *Brachiaria*. The quality, quantity, and resistance to biotic and abiotic stress of this grass have all been genetically enhanced in Latin America. Many hectares of it are currently sown in South American nations for cattle production operations. This improved Brachiaria grass has recently been introduced to Africa, where it originated, particularly in Eastern and Southern Africa, where it is being tested on-farm with the help of farmers (Maass et al., 2015. The optimum method for evaluating a crop-

livestock based technology in African farm circumstances has been found by numerous researchers through participatory approaches; for profitability and sustainability, this should be incorporated into the current farming system (Waldman et al., 2014; Coromaldi et al., 2015).

Brachiaria has hardly ever been the subject of animal performance research in Southern Africa. Brachiaria grasses need to be tested in controlled environments at research facilities like the Grasslands Research Institute as well as on farms in smallholder dairy communities as a base feed for lactation cows. To completely comprehend the advantages of Brachiaria grass in tropical climates, additional research is required to determine nitrogen retention and efflux, as well as milk fat and protein. In order to identify the Brachiaria grass cultivars that are adapted to all of Zimbabwe's agroecologies, as well as any potential alterations brought on by climate change, a forage suitability map for the Zimbabwe must also be created. Utilizing contemporary tools and methods, a national inventory and mapping of naturally occurring species with potential agricultural applications can be beneficial for the production of livestock. Using the demonstration plots paradigm, it is also necessary to develop secondary fodder multiplication sites adjacent to farmers.

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Author's Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*
Conceived and designed the research or analysis	Yes	Yes	Yes	Yes	Yes
Collected the data	Yes	No	No	No	No
Contributed to data analysis & interpretation	Yes	No	No	Yes	Yes
Wrote the article/paper	Yes	No	No	No	No
Critical revision of the article/paper	Yes	Yes	Yes	Yes	Yes
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